CLIMCAPS Status

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Oct. 2, 2020

NASA Sounder Meeting

CLIMCAPS operational sounding products benefit from NOAA R2O of NASA algorithms

AIRS v5.9 (2007) ⇒ NUCAPS (2008+) ⇒ CLIMCAPS (2019) ⇒ NUCAPS •••

	NASA CLIMCAPS	NOAA NUCAPS
A-priori	MERRA-2 for T(p), q(p), O3(p)	Global regression (i.e., model independent)
Error propagation	Eigenvector expansion of full 2-D covariance	1-D diagonal w/ specified vertical “oscillation”
Supported systems	• S-NPP NSR & FSR full mission • JPSS-1 (NOAA-20) full mission • Aqua full mission, end of 2020	• Metop –A, -B, -C • S-NPP FSR • JPSS-1 (NOAA-20)
Latency	~1 month (wait f/ MERRA)	Real time (~30 minutes)
Averaging Kernels?	YES – fully supported	Not operational, but can provide via science code

NUCAPS = NOAA-Unique Combined Atmospheric Processing System
CLIMCAPS = Community Long-term Infrared Microwave Coupled Atmospheric Product System

Retrieval products in CLIMCAPS
Information content analysis is "built-in

Core Retrieval Product	Spectral Region (cm^{-1})
Temperature, T	650-750, 2200-2400
Water Vapor, q	1200-1650
Ozone, O_3	990 – 1070
Carbon Monoxide, CO	2155 – 2220
Methane, CH_4	1220 – 1350
Carbon Dioxide, CO_2	660 – 760 2200 – 2400

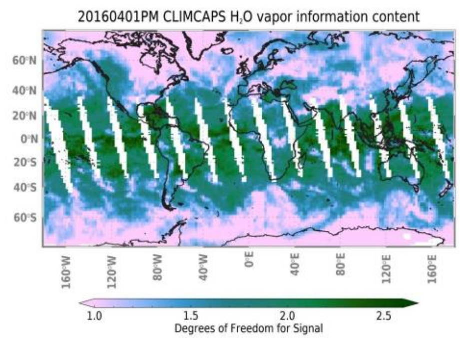
Experimental trace gas profiles

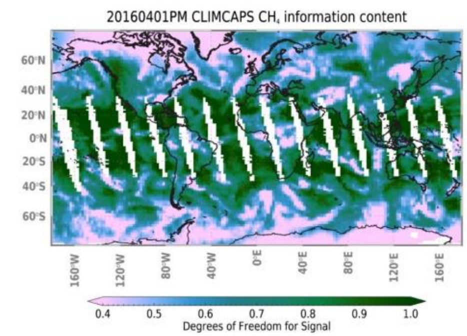
Nitric Acid, HNO_3	760 – 1320
Nitrous Oxide, N_2O	1290 – 1300 2190 – 2240
Volcanic Sulfur Dioxide, SO_2	1343 – 1383

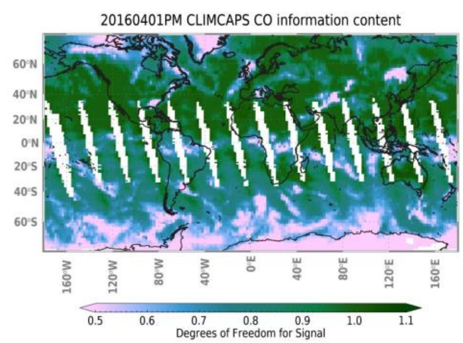
Experimental Single-FOV detection flags

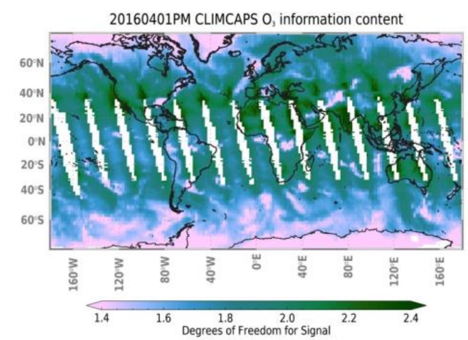
Isoprene (C_5H_8)	893.8
Ethane (C_2H_6)	822.5
Propylene (C_3H_6)	911.9
Ammonia (NH_3)	966.25 + 928.75

Example of product degrees of freedom



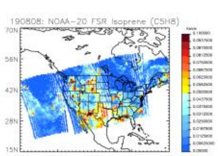




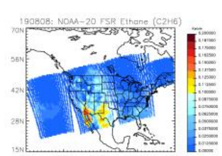


Example of experimental detection flags

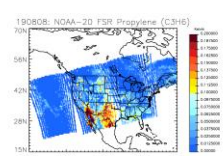
Isoprene



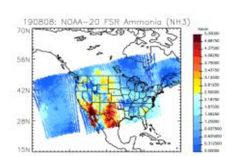
Ethane



Propylene



Ammonia



CLIMCAPS Version.2 at NASA GES-DISC for full missions of S-NPP and JPSS-1

Short Name	DOI	Description
SNDRSNIML2CCPRETN	10.5067/9HR0XHCH3IGS	Geophysical state derived from Suomi-NPP ATMS + CrIS NSR
SNDRSNIML2CCPCCRN	10.5067/CNG0ST72533Z	Cloud Cleared Radiances derived from Suomi-NPP CrIS NSR
SNDRSNIML2CCPRET	10.5067/62SPJFQW5Q9B	Geophysical state derived from Suomi-NPP ATMS + CrIS FSR
SNDRSNIML2CCPCCR	10.5067/ATJX1J10VOMU	Cloud Cleared Radiances derived from Suomi NPP CrIS FSR
SNDRJ1IML2CCPRET	10.5067/LESQUBLWS18H	Geophysical state derived from JPSS-1 (NOAA-20) ATMS + CrIS
SNDRJ1IML2CCPCCR	10.5067/KE4WCXM829A3	Cloud Cleared Radiances derived from JPSS-1 (NOAA-20) CrIS

Note: NSR = Nominal Spectral Resolution, FSR = Full Spectral Resolution
Went "live" at NASA/GES-DISC in April 2019

We expect to deliver version 3 in late spring 2021 (at end of current funding)

- Mitigate differences between Aqua, S-NPP, and JPSS-1 systems
  - Upgrade to AIRS v.7 L1c, CrIS v.3 L1b
  - Analysis of v.2 information content to optimize regularization, functions, channels, etc.
    - Homogenize averaging kernels across satellite domains
- Finish 2-D error propagation of T/q/O_3 into downstream trace gases
  - Use NOAA CO_2, CH_4, and N_2O a-priori (J. Warner
- Improve surface a-priori and retrieval
  - Improve PBL sensitivity

For More Information

CLIMCAPS *Science* User Guides (will be available soon):

- Complements the *Product* User Guides, ATBD's and papers
- Online wiki-like format: https://airs-guide.jpl.nasa.gov
- Guides on products (H_2O, O_3, CO, etc.) and use (averaging kernels, etc.)
- A "living" document to describe theory, algorithm details, caveats, etc.

Recent Publications (all open access)

(Smith and Barnet 2019 Remote Sensing) CLIMCAPS Algorithm paper

https://www.mdpi.com/2072-4292/11/10/1227

(Smith and Barnet 2020 Atm. Meas. Tech.) CLIMCAPS Information Content

https://amt.copernicus.org/articles/13/4437/2020/

(Esmaili et al. 2020 Remote Sensing) NUCAPS Weather Applications

https://www.mdpi.com/2072-4292/12/5/886

Want to know more? Presentations at this meeting

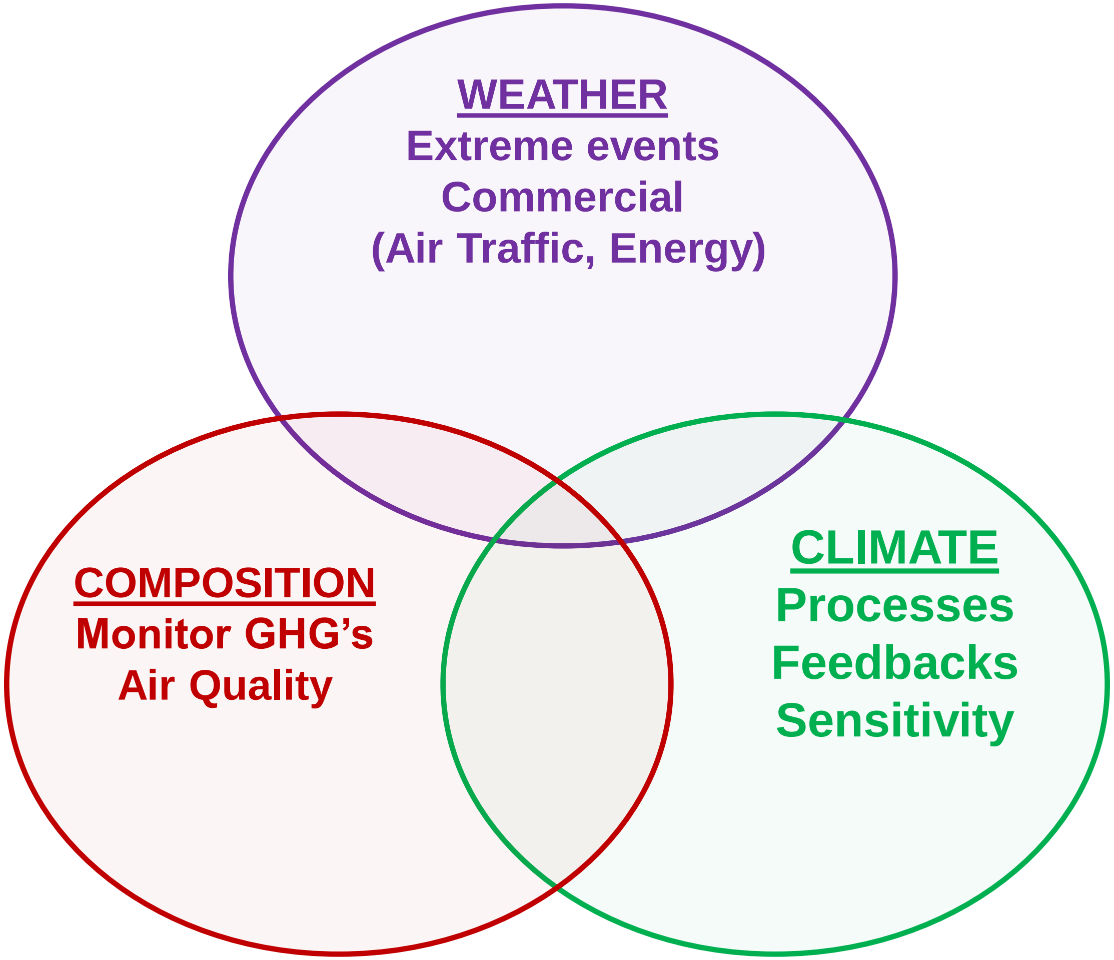
- CLIMCAPS Evaluation
  - Oct. 8 9:00 PDT Nadia Smith CLIMCAPS overview
  - Oct. 8 10:50 PDT Sun Wong – CLIMCAPS/Aqua & AIRS v.7
  - Oct. 8 11:10 PDT Tao Wang – CLIMCAPS/S-NPP & JPSS-1

- CLIMCAPS user engagement
  - Oct. 13 10:00 PDT Brad Smith, CO, O_3
  - Oct. 13 10:55 PDT Nadine de Bruyn, CO
  - Oct. 13 11:20 PDT Irina Petropavlovskikh, O_3 and others
  - Oct. 13 11:20 PDT Nadia Smith, O_3

- NUCAPS user engagement
  - Oct. 15 10:10 PDT Erika Duran, Cylones
  - Oct. 15 10:35 PDT Jeff Szkodzinky, real-time NUCAPS T/q
  - Oct. 15 10:10 PDT Emily Berndt, NUCAPS-Aqua

Backup Slides

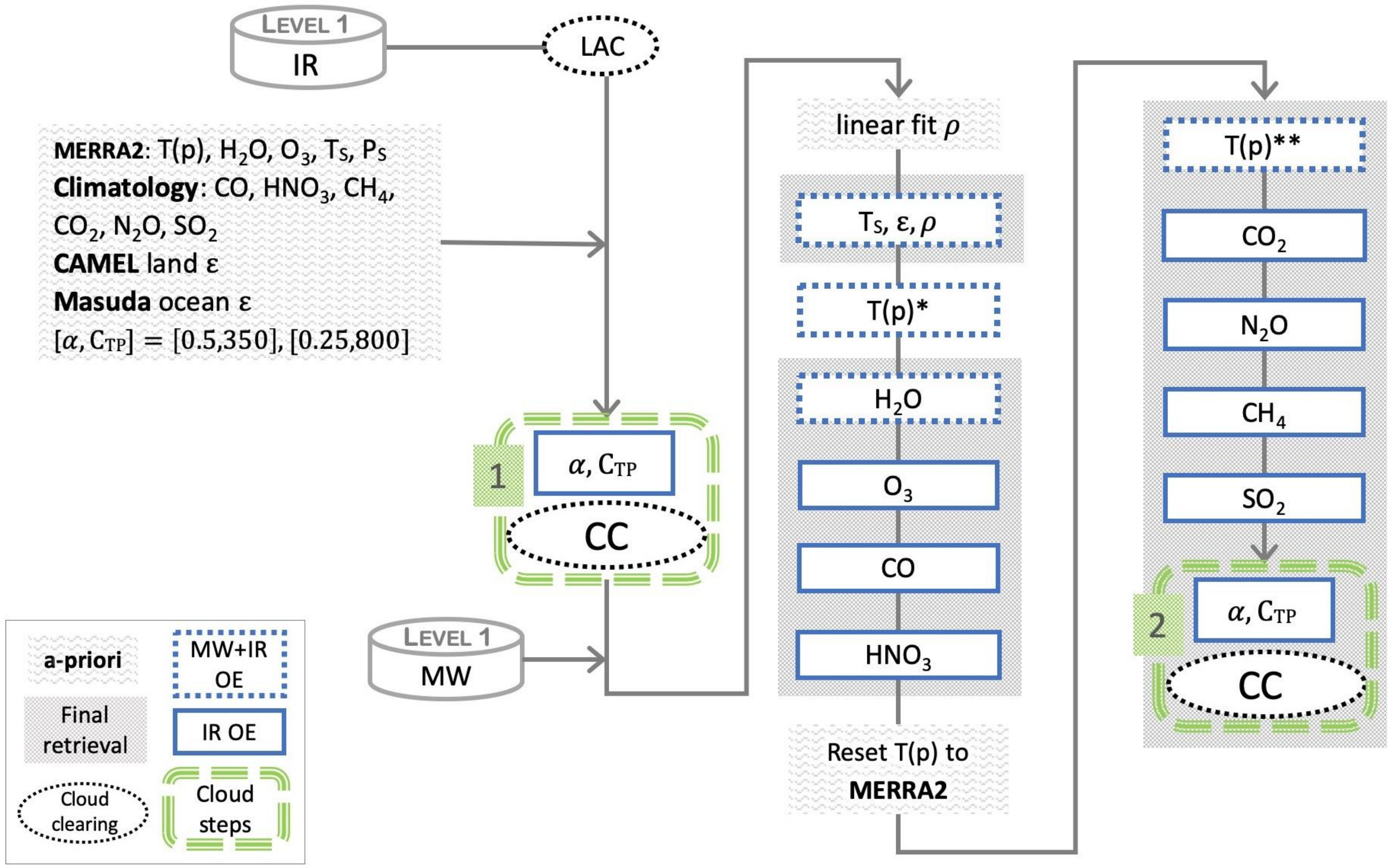
Together these algorithms can ***contribute*** to the needs of three communities



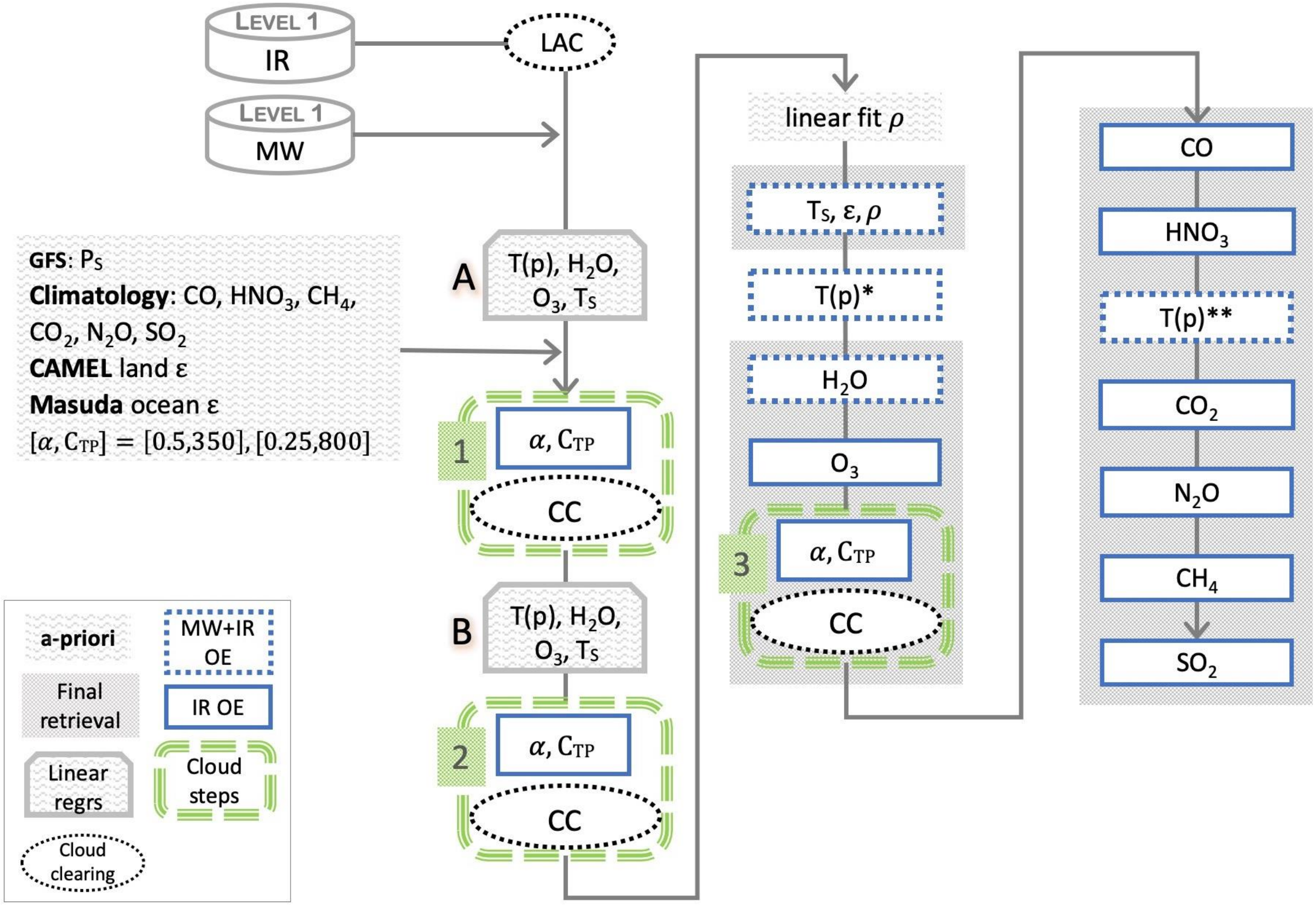
Relevant ROSES-TASNPP funded research activities at NASA – 2018-2020 cycle

- Larrabee Strow (UMBC) Climate anomalies of CO2, CH4, N2O, etc. from CrIS and AIRS
- Helen Worden (UCAR): Extend MOPITT Carbon Monoxide from CrIS + TROPOMI
- Karen Cady-Pereira (AER) and David Henze (U.Colorado): Ammonia retrieval and inverse modeling from CrIS
- Vivienne Payne: Peroxyacetyl Nitrate (PAN) retrievals from CrIS

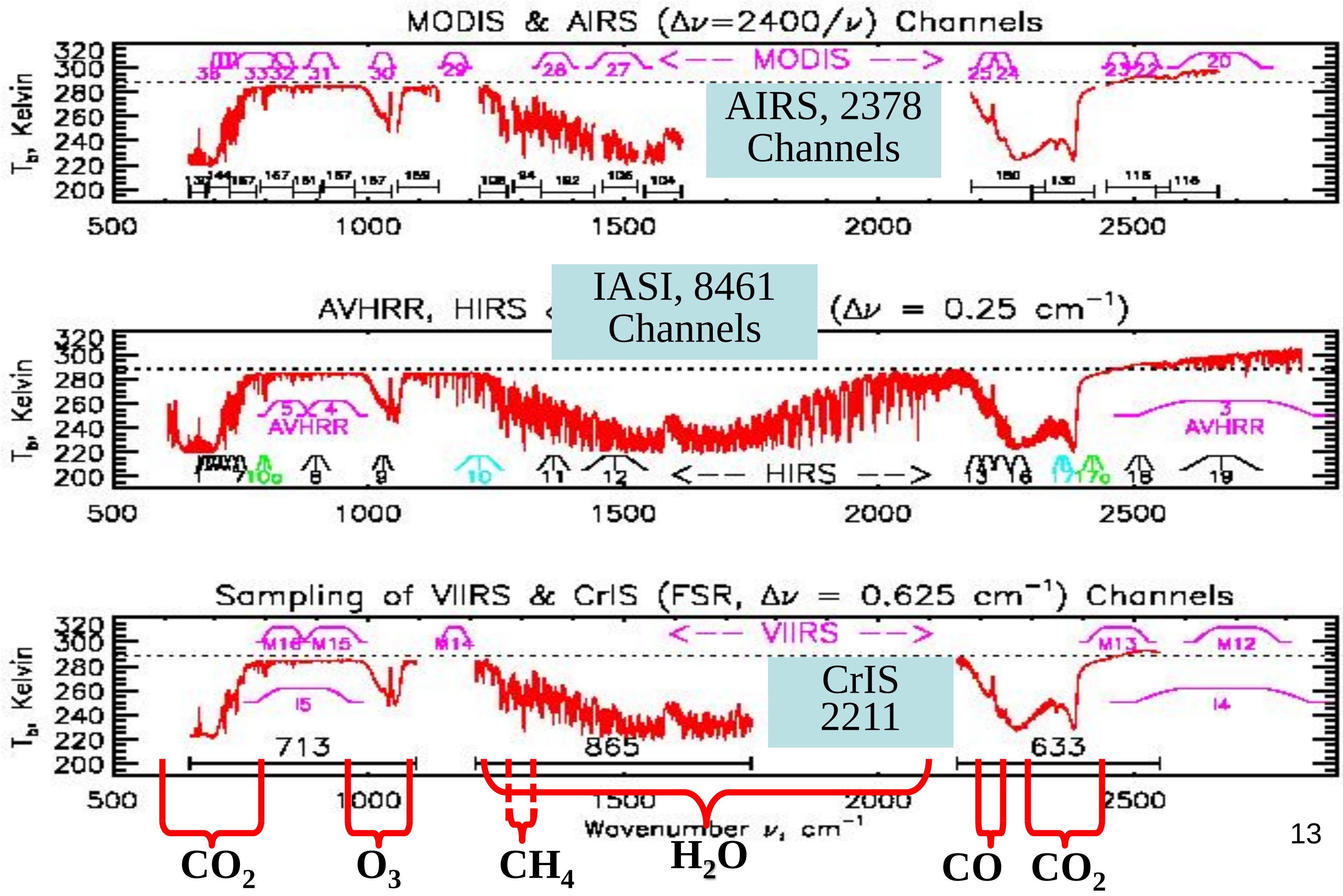
Simplified CLIMCAPS Flow Diagram



Simplified NUCAPS Flow Diagram

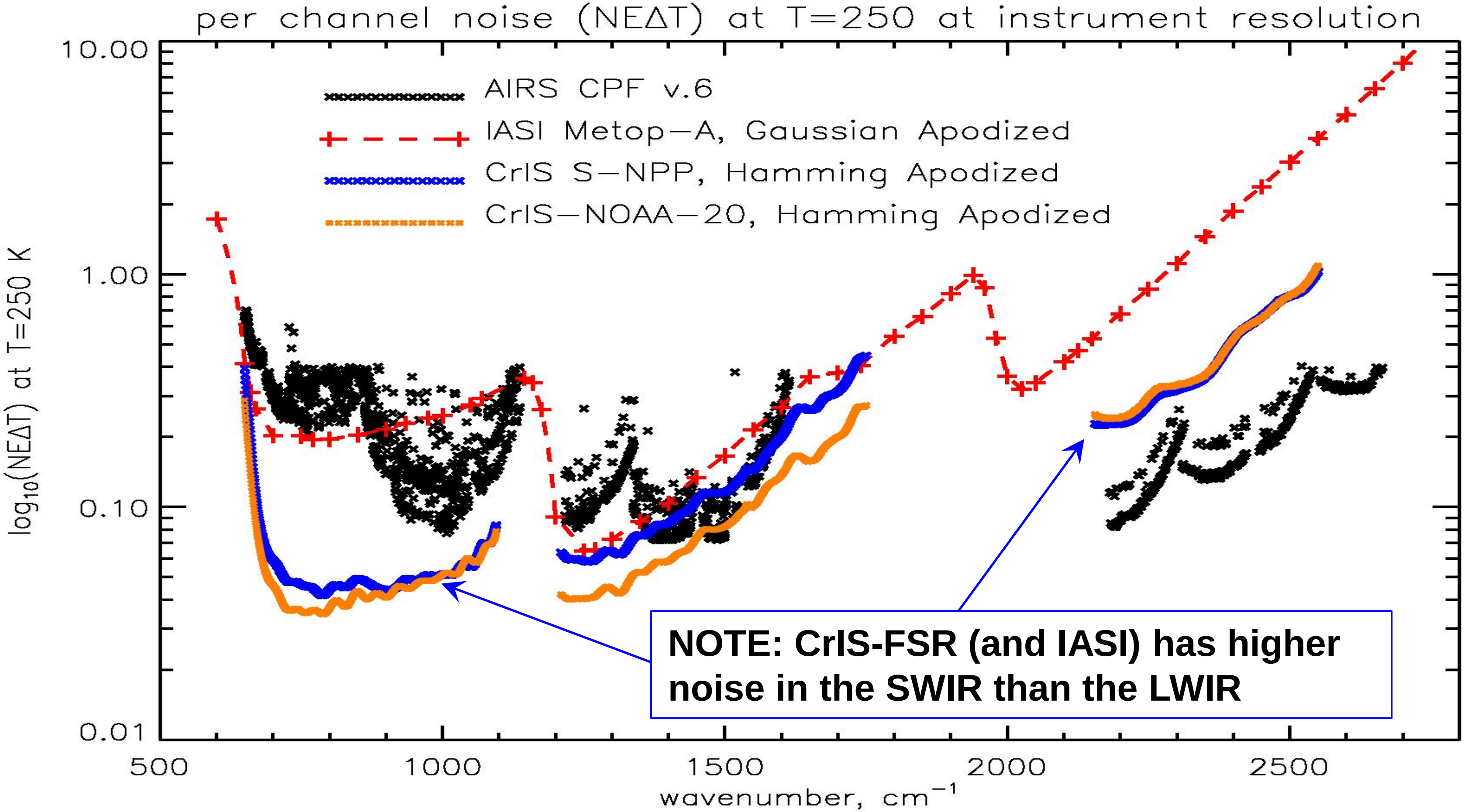


Spectral Coverage of Thermal Sounders & Imagers (Aqua, Metop-A,B,C, Suomi-NPP, NOAA-20+)



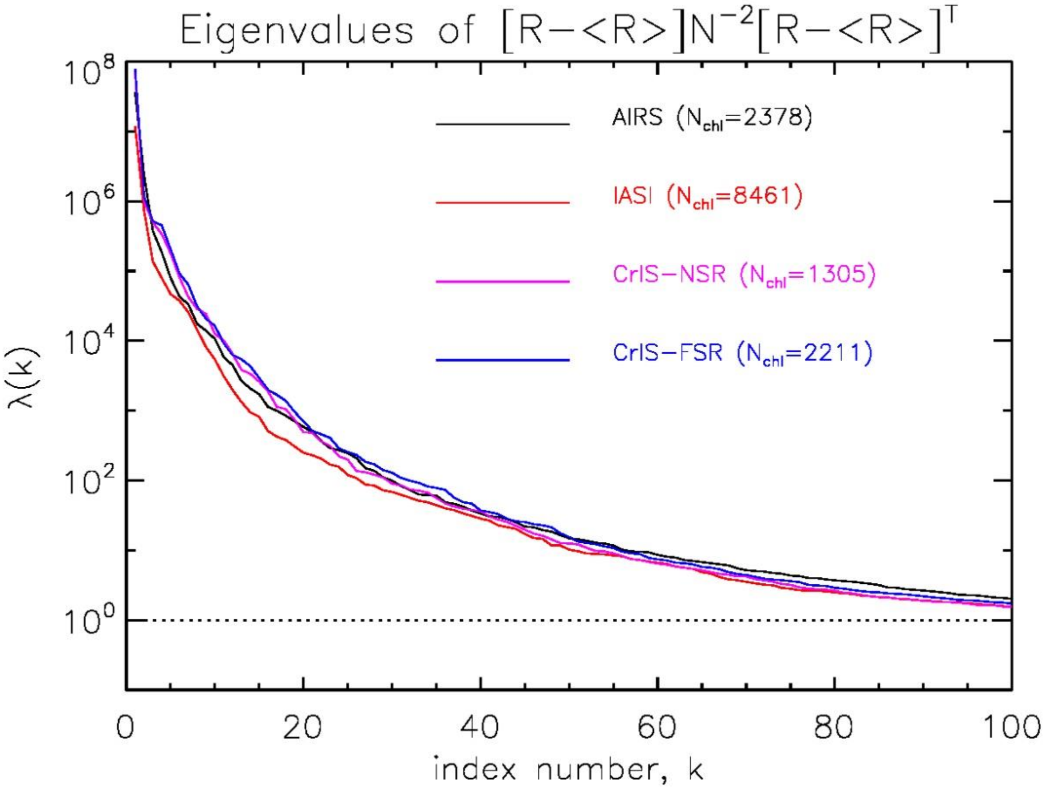
What is important for sounding is signal to noise

Per channel noise is shown as noise equivalent delta temperature (NEΔT) at a cold scene temperature (T=250 K)



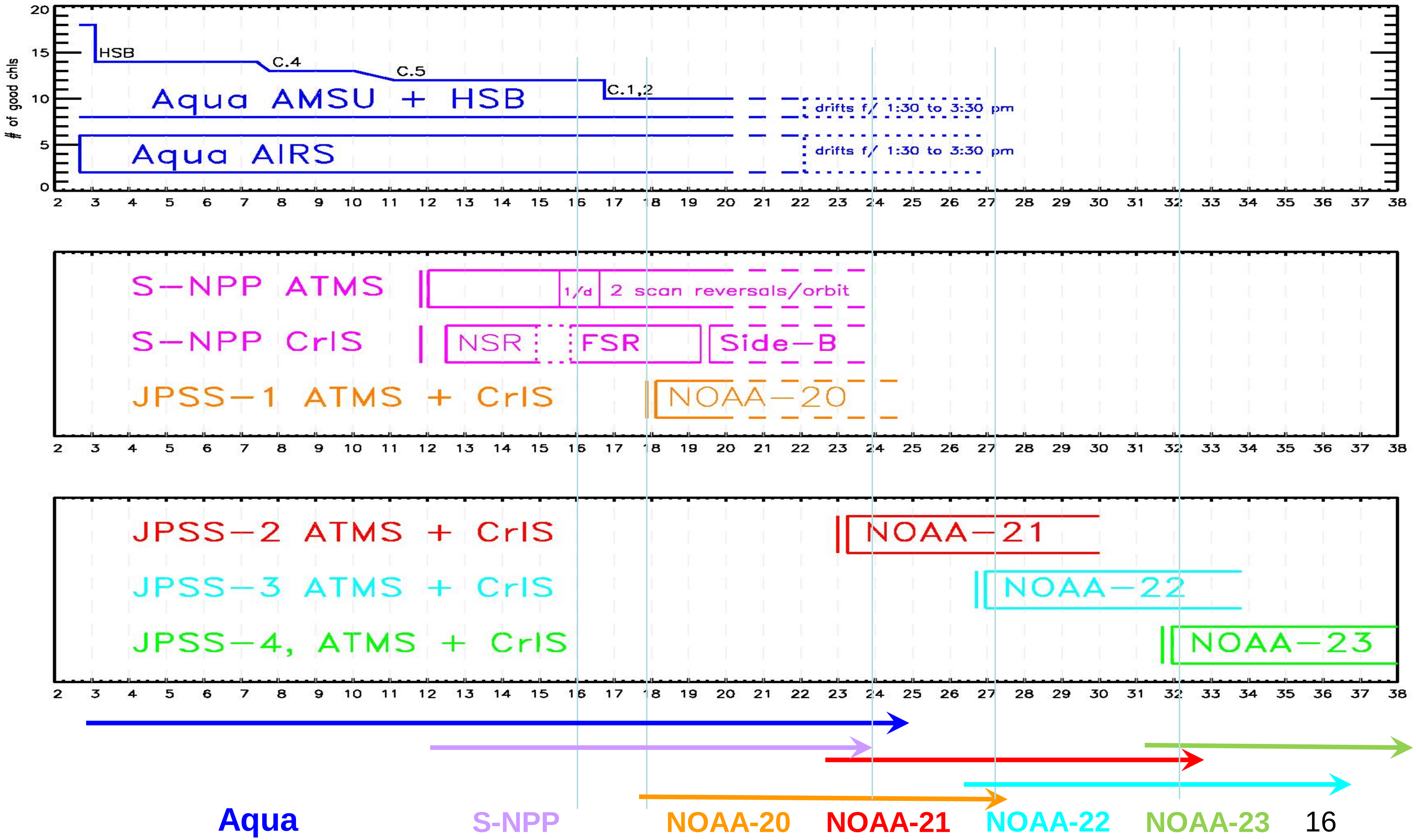
The information content of modern sounding instruments is ***amazingly*** similar

- AIRS, IASI, and CrIS each have ~100 degrees of freedom
- Even though AIRS, IASI, and CrIS have different number of channels, ILS, noise, etc.



The 1st 100 significant eigenvectors of radiance covariance for a set of focus days normalized at λ(k=200)

Choosing the cross-over points for Aqua, S-NPP, NOAA-20 and beyond



Applications we are NOT targeting with NUCAPS & CLIMCAPS.

Topic	Potential applications for thermal sounding products
Long term GHG trends	• For GHG-relevant gases we have very low information content. • We relax to a-priori assumptions so we only see ~50% of the signal. • Large cross-talk between CO2/T, N2O/T, CH4/q, etc. • Recommend using other products for trends • For example, Larrabee Strow's radiance anomaly product (also funded by NASA TASNPP)
GHG Emissions Monitoring	• We have very low (and variable) sensitivity in the PBL • Most of our PBL information content comes from a-priori assumptions. • We complement the information content of passive solar sensors.
High spatial resolution approaches for trace gases.	• Clouds are still a major obstacle for infrared sounding. • NU/CLIMCAPS are intended as global quick look products. • NU/CLIMCAPS can be used as "triggers" for more advanced algorithms • could use CLIMCAPS to launch specialty algorithms (e.g., NASA TASNPP or AC4 funded algorithms, MUSES, etc.)

Applications we are targeting with NUCAPS & CLIMCAPS.

Topic	Potential applications for thermal sounding products
T(p), q(p) sounding and data assimilation	Knowledge of CO_2, O_3, HNO_3, N_2O needed to derive T(p) Knowledge of CH_4, N_2O, SO_2 needed to derive q(p)
GHG Monitoring	Enhance the boundary layer sensitivity of passive solar retrieval products.
Ozone	Ozone hole; intrusions and mid-trop O_3 (Langford 2018 Atmos. Env); LS O_3 trends (Ball 2018 ACP, Wargan 2018 GRL); CO/O_3 ratio (Anderson 2016 Nat.Comm)
Carbon Dioxide (CO_2)	Seasonal cycle amplitude (Barnes 2016 JGR), Clear bias and diurnal "rectifier" effects (Corbin 2008 JGR), and stratospheric/troposphere CO_2 gradient. Evaluation of transport models (mixing into mid-trop, etc.). Note that separability of T/CO_2 is significantly improved with use of Merra-2 a-priori and with AMSU/ATMS O_2 bands for T(p)
Carbon Monoxide	Long-term trends of CO (Worden 2013 ACP). Impact on OH (Gaubert 2017 GRL), Seasonal cycle (Park 2015 JGR) and CO/CO_2 emission factors (Wang 2009 ACP)
Methane (CH_4)	Monitoring of Amazon CH_4 (Bloom 2016 ACP), Changes to Arctic emissions (Shakhova 2010 Science, Thornton 2016 GRL)
Other trace gases	Nitric Acid, Nitrous Oxide, Sulfur Dioxide are supported with experimental retrievals. Ammonia, Isoprene, Ethane, and Propylene are potentially useful as tracer-tracer correlations, emission ratios (errors tend to cancel), source type identification, etc.